TG: @Chalnaayaaar

Kinematics

SOLUTIONS

BEGINNER'S BOX-1

1. t = 2 min 20 sec = 120 + 20 = 140 sec

after each complete rotation, displacement becomes zero.

Number of rotation = $\frac{140}{40} = 3 + \frac{1}{2}$

$\therefore$ displacement in $\frac{1}{2}$ rotation = 2r

(displacement for 3 rotation = 0)

Distance in $3 + \frac{1}{2}$ rotation = $3 \times 2\pi r + \pi r = 7\pi r$

2. Since displacement is independent of path, the displacement is the shortest distance between initial position & final position. So the displacement for each girl will be 400 m. For girl 'B' the displacement will be equal to actual path length

3. Distance = 4 + 3 + 12 = 19 m

displacement = $\sqrt{4^2+3^2+12^2}$ = 13 m

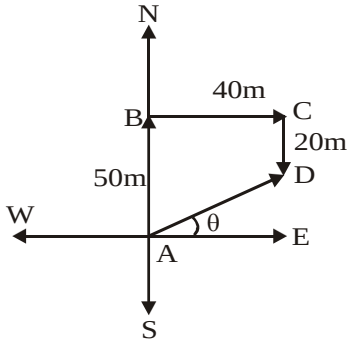
4. Distance = path length = $\frac{1}{2}$ × circumference

$= \frac{1}{2} \times 2\pi R = \pi R = (40\pi)$ m,

Displacement $= \left|\vec{d}\right| = 2r = 80$m

5. (A) Total distance travelled = 50m + 40m + 20m = 110m

(B) Let east direction is $\hat{i}$ and north direction is $\hat{j}$ then $\vec{AB} = 50\hat{j}, \vec{BC} = 40\hat{i}, \vec{CD} = -20\hat{j}$



According to law of polygon

$\vec{AD} = \vec{AB} + \vec{BC} + \vec{CD}$

$\vec{AD} = 50\hat{j} + 40\hat{i} - 20\hat{j} = 40\hat{i} + 30\hat{j}$

$|\vec{AD}| = \sqrt{40^2+30^2} = 50$m

Now, if angle of $\vec{AD}$ with east towards north is θ, then

$\tan\theta = \frac{30}{40} = \frac{3}{4}$, so $\theta = \tan^{-1}\left(\frac{3}{4}\right) = 37°$

So direction of displacement is E 37° N (37° N of E)

BEGINNER'S BOX-2

1. Air distance (shortest distance)

= displacement = 260 km

Road distance = 320 km

(i) Average speed of bus = $\frac{\text{Total distance}}{\text{total time}}$

$= \frac{320}{8}$

= 40 km/h

(ii) Average velocity of bus

$= \frac{\text{Total displacement}}{\text{Time}} = \frac{260}{8}$

= 32.5 km/h

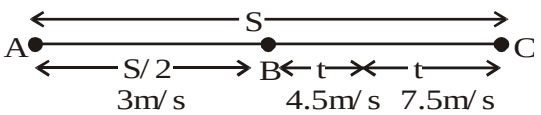
(iii) Average speed of plane

$= \frac{260}{\frac{1}{4}} = 1040$ km/h

(iv) Average velocity of aeroplane = $\frac{260}{1/4}$

=1040km/h

2.



Average speed from B to C

$(v_{Avg})_{B \to C} = \frac{4.5 \times t + 7.5 \times t}{2t}$

$(v_{Avg})_{B \to C} = 6$ m/s

Average speed from A to C

$$(v_{Avg})_{A \to C} = \frac{\frac{S}{2}+\frac{S}{2}}{\frac{S}{2\times3}+\frac{S}{2\times6}}$$

$(v_{Avg})_{A \to C} = 4$ m/s

3. **Between 6:00 A.M. to 6:30 A.M.**

In this time interval the tip of minute hand moves from (12 mark) to (6 mark).

$\therefore$ displacement

= 2 × (length of minute hand)

= 2 × 4.5 cm = 9 cm

and time taken (t) = 30 min = 30 × 60 = 1800s

$\therefore$ average velocity

$$= \frac{S}{t} = \frac{9}{1800} = 5\times10^{-3}\,cm/s$$

direction of average velocity is from 12 mark to 6 mark on the clock panel.

Between 6:00 A.M. to 6:30 P.M.

In this time interval also minute hand will move from (12 mark) to (6 mark).

$\therefore$ displacement

= 2 × (length of minute hand)

= 2 × 4.5 cm = 9 cm

and time taken (t) = 12 hrs and 30 minute

= (12 × 60 × 60)s + (30 × 60)s

= 43200 s + 1800 s = 45000 s

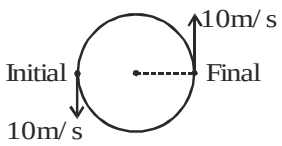
$\therefore$ average velocity

$$= \frac{s}{t} = \frac{9}{45000} = 2\times10^{-4}\,cm/s$$

direction of average velocity is from 12 mark to 6 mark on the clock panel.

4. Change in speed

Δv = 10 – 10 = 0 Change in velocity



$$\Delta\vec{v} = \vec{v}_f - \vec{v}_i$$

$$= 10\hat{j} - (-10\hat{j}) = 20\hat{j}$$

Magnitude $|\Delta\vec{v}| = 20\,m/s$

5. (a) The distance travelled during time 0 to 5.0s is, S = (2.5) $(5.0)^2$ = 62.5 m

The average speed during this time is

$$v_{avg} = \frac{\text{distance travelled}}{\text{time taken}} = \frac{62.5}{5} = 12.5\ m/s$$

(b) Given $S = (2.5)t^2$

$$\text{Instantaneous speed} = \frac{dS}{dt} = \frac{d}{dt}(2.5t^2) =$$

(2.5) (2t) = 5t

At t = 5.0 s the speed is

$[v]_{t=5S}$ = (5.0) × (5.0) = 25 m/s

6. Average velocity

$$= \frac{\text{Net displacement}}{\text{total time}} = \frac{AO+OB}{\text{time}}$$

$$= \frac{1+1}{1} = 2\ m/s$$

7. (a) Average speed = $\frac{\text{Total path length}}{\text{Total time}}$

$$= \frac{23}{(28/60)} = 49.3\ kmh^{-1}$$

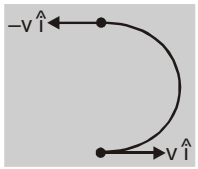
(b) Average velocity = $\frac{\text{Displacement}}{\text{Time}}$

$$= \frac{\text{Shortest distance}}{\text{Time}} = \frac{10}{28/60} = 21.4\ km/h$$

(c) Both are Not equal

BEGINNER'S BOX-3

1. $t = \frac{\pi R}{v} = \frac{\pi\times5}{5} = \pi$ sec



$$\Delta\vec{v} = (-5\hat{i}) - (5\hat{i}) = -10\hat{i}$$

$$\vec{a}_{avg} = \frac{\Delta\vec{v}}{t} = \frac{-10\hat{i}}{\pi} \Rightarrow \left|\vec{a}_{avg}\right| = \frac{10}{\pi}\ m/s^2$$

2. $x = 7t^2 - 2t + 5$

(a) $v = \frac{dx}{dt} = 14t - 2$

at t = 5, v = 14 × 5 – 2 = 68

(b) $a = \frac{dv}{dt} = 14$

(c) Average velocity

TG: @Chalnaayaaar

$= \frac{\text{displacement}}{\text{Time}} = \frac{x_5 - x_0}{5-0}$

$x_5 = 7(5)^2 - 2(5) + 5 = 170$

$x_0 = 7(0)^2 - 2(0) + 5 = 5$

$v_{Avg} = \frac{170-5}{5} = 33$

(d) Average acceleration

$= \frac{\text{Change in velocity}}{\text{Time interval}} = \frac{v_5 - v_0}{5-0}$

$v_5 = 14 \times 5 - 2 = 68$

$v_0 = 14 \times 0 - 2 = -2$

$a_{Avg} = \frac{68-(-2)}{5-0} = 14$

BEGINNER'S BOX-4

1. Let $a = a_0$ & $u = 0$

So $S_1 = 0 + \frac{1}{2} a_0 (5)^2 = \frac{25}{2} a_0$

distance covered in 15 sec.

$S_1 + S_2 = \frac{1}{2} a_0 (15)^2 = \frac{225}{2} a_0$

$S_2 = \frac{225}{2} a_0 - \frac{25}{2} a_0 = 100 a_0$

$\frac{S_1}{S_2} = \frac{\frac{25}{2} a_0}{100 a_0} = \frac{1}{8} \Rightarrow S_1 = \frac{S_2}{8}$

2. $v^2 = u^2 + 2aL$ (L is length of train)

$2aL = v^2 - u^2$

For mid point

also $v_m^2 = u^2 + 2a\frac{L}{2} = u^2 + \frac{1}{2}(v^2 - u^2)$

$v_m^2 = \frac{2u^2 + v^2 - u^2}{2} = \frac{u^2 + v^2}{2}$; $v_m = \sqrt{\frac{u^2 + v^2}{2}}$

3. By using $v^2 = u^2 + 2as$

We have $\left(u - \frac{u}{n}\right)^2 = u^2 + 2(-a)s$

$\left(\frac{2}{n} - \frac{1}{n^2}\right) u^2 = 2as$

Let no. of planks required be N

Then,

$0^2 = u^2 + 2(-a)Ns$

Therefore, $\left(\frac{2}{n} - \frac{1}{n^2}\right) u^2 = \frac{u^2}{N}$

$N = \frac{n^2}{2n-1}$

4. initial velocity $u = 126 \times \frac{5}{18} = 35$ m/s,

$s = 200$ m

From equation of motion $v^2 = u^2 + 2as$

$\Rightarrow 0 = (35)^2 + 2a \times 200 \Rightarrow a = -3.06$ m/s^2

$\therefore$ retardation is 3.06 m/s^2

$v = u + at$; $0 = 35 - 3.06\, t$

$t = 11.4$ sec.

5. During the reaction time, the car will move with constant speed.

So, $S_1 = ut$

The distance covered by the car after brakes are applied $S_2 = \frac{0^2 - u^2}{-2a} = \frac{u^2}{2a}$

So Total distance travelled $= S_1 + S_2 = ut + \frac{u^2}{2a}$

6. $S_{n^{th}} = u + \frac{1}{2} a(2n-1)$

$1.2 = 0 + \frac{1}{2} \times a \times 11$;

$a = \frac{2.4}{11}$ m/s^2; $a = 0.218$ m/s^2

BEGINNER'S BOX-5

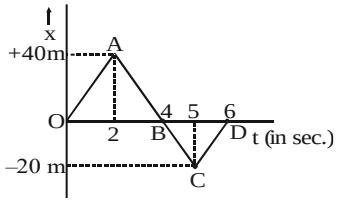
1. Velocity = Slope of s – t curve

So $\frac{v_A}{v_B} = \frac{\text{Slope of A}}{\text{Slope of B}} = \frac{\tan 30^\circ}{\tan 60^\circ} = \frac{1}{3}$

2. (i) Total distance travelled

$= x_{OA} + x_{AB} + x_{BC} + x_{CD}$

$= 40 + 40 + 20 + 20 = 120$ m

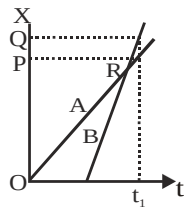


(ii) Displacement = final position – initial position = $x_D - x_O = 0 - 0 = 0$

(iii) Average speed $= \frac{\text{Total distance}}{\text{Total time}} = \frac{120}{6} =$ 20 m/s

(iv) Average velocity $= \frac{\text{displacement}}{\text{Time}} = \frac{0}{6} = 0$ m/s

3.



(a) A lives closer to the school than B (as P is close to O than Q)

(b) A starts earlier than B (A starts when time t = 0)

(c) B walks faster than A (slope of B is greater than slope of A)

(d) A and B reach home at the same time t_1 (as shown by dotted lines in the graph)

(e) B overtakes A on the road once (as graphs for A and B intersect only at one point R.)

4. (i) Total distance covered = Area under v – t curve

$$\frac{1}{2} = (2 \times 2) + 2(4-2) + \frac{1}{2}(10+2) \times 1$$

$$\frac{1}{2} \times 5 \times 10 = 37\text{m}$$

(ii) $\text{Average speed} = \frac{\text{Total distance}}{\text{Total time}} = \frac{37}{10} = 3.7\text{ m/s}$

(iii) Acceleration = Slope of v – t curve

So maximum acceleration will be in the part where the slope will be maximum i.e. BC

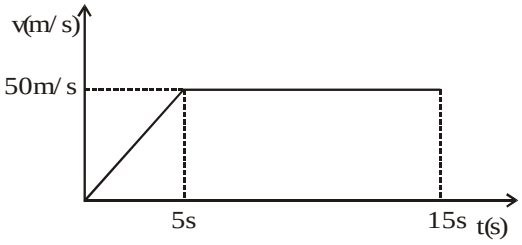
$$a_{max} = a_{BC} = \frac{10-2}{1} = 8\text{m/s}^2$$

(iv) Retardation = Slope of CD (As it is negative)

$$= \left|\frac{0-10}{5}\right| = |-2| = 2\text{m/s}^2$$

5. Velocity after 5 seconds = 0 + 10 × 5
= 50m/s

v – t curve for the situations is as follows :



Total distance travelled = Area under v-t curve

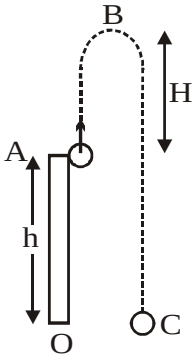
$$= \frac{1}{2}(50 \times 5) + 50 \times (15-5) = 625\text{m}$$

BEGINNER'S BOX-6

1. Time taken to reach the highest point = $\frac{u}{g}$

$$t = \frac{10}{10} = 1\text{s}$$

2. Time taken to reach B



$$t_{AB} = \frac{u}{g} = \frac{10}{10} = 1\text{ sec.}$$

t_{AC} = 5sec. (given)

so $t_{BC} = 5 - 1 = 4$ sec.

$$S_{BC} = \frac{1}{2}gt^2 = \frac{1}{2}(10)(4)^2$$

$$= 80\text{ m}$$

$$S_{AB} = \frac{u^2}{2g} = \frac{(10)^2}{20} = 5\text{m}$$

(a) Height of tower h = 80 – 5 = 75 m

(b) $v_c = 0 + gt_{BC} = 40$ m/s

(c) Distance travelled = 5 + 80 = 85 m

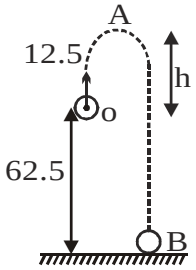
(d) Average speed = $\frac{85}{5} = 17$ m/s

Average velocity = $\frac{75}{5} = 15$ m/s

3. Velocity of balloon after 10 sec. = 0 + 1.25 × 10
= 12.5 m/s

distance travelled = $\frac{1}{2}at^2 = \frac{1}{2}(1.25) \times 10^2$

= 62.5 m



(i) $h = \frac{u^2}{2g} = \frac{(12.5)^2}{20} = 7.8125\text{ m}$

height from ground=62.5+7.8125=70.31 m

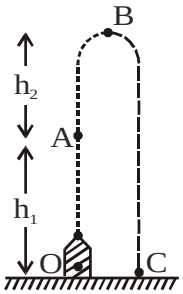
TG: @Chalnaayaaar

(ii) $t_{OA} = \frac{u}{g} = \frac{12.5}{10} = 1.25$ sec.

$t_{AB} = \sqrt{\frac{2h_{AB}}{g}} = 3.75$ sec.

Total time = 5 sec.

4. Point O → Point of projection



Point A → Point up to which fuel is consumed.

Point B → Highest point of path

$h_1 = 0 \times 60 + \frac{1}{2} \times 10 \times (60)^2$

$= 18$ km

$v_A = 0 + 10 \times 60 = 600$ m/s

$0 = v_A^2 - 2gh_2 \Rightarrow h_2 = \frac{v_A^2}{2g} = \frac{(600)^2}{20} = 18$ km.

maximum height from ground = 18 + 18 = 36 km.

time taken from A to B :→ $0 = 600 - gt \Rightarrow t =$ 60 sec.

time taken in coming down to earth –

$36000 = \frac{1}{2} gt^2 \Rightarrow t = 60\sqrt{2}$ sec.

$\therefore$ Total time = $60 + 60 + \sqrt{2}\,60 = 60(2 + \sqrt{2})$ s.

$= (2 + \sqrt{2})$ min.

5. Let it takes n seconds to fall from tower then

total distance $s = \frac{1}{2} g (n)^2$

distance travelled in n^{th} second

$s_{n^{th}} = 0 + \frac{g}{2}(2n - 1) \Rightarrow s_{n^{th}} = \frac{9}{25} s$

$\Rightarrow \frac{g}{2}(2n - 1) = \frac{9}{25}\frac{g}{2}(n^2) \Rightarrow 9n^2 = 50n - 25$

$\Rightarrow n = \frac{50 + \sqrt{50^2 - 4 \times 9 \times (+25)}}{2 \times 9} = 5$ sec.

$H = \frac{1}{2} g(5)^2 = 125$ m

6. Let the particle covers its total journey in n seconds then for last 2 sec.

$S_n - S_{n-2} = 40$ m

$\frac{1}{2} g(n)^2 - \frac{1}{2} g(n-2)^2 = 40$

$\Rightarrow (4n - 4) = 8 \Rightarrow n = 3$

height of tower $= \frac{1}{2} g(3)^2 = 45$ m

7. (a) Acceleration is directed downwards

(b) At highest point v = 0, a = g (downwards)

(c) For upward motion (Reference point to be the highest point, taking downward direction positive)

x → Positive

→ negative

a → positive

For downward motion

x → Positive

v → Positive

a → Positive

(d) $H = \frac{v^2}{2g} = 44.1$ m, $T = \frac{2v}{g} = 6$ sec.

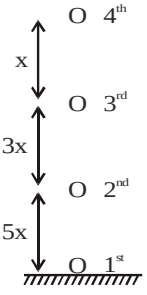
8. Let time of fall be 'n'

$\frac{1}{2} g(2n - 1) = \frac{1}{2} g (3)^2$

$\Rightarrow n = 5$ sec.

Height of tower $= \frac{1}{2} g(5)^2 = 125$ m.

9. By galileo's law of odd number



x + 3x + 5x = 9m

x = 1 m

Position of 2nd drop from top

x + 3x = 4x = 4m

Position of 3rd drop from top

x = 1 m

BEGINNER'S BOX-7

1. (a) Time taken by the ball to reach the highest point

$$t = \frac{T}{2} = \frac{u\sin\theta}{g} = \frac{20}{10} \times \sin 30°$$

(b) The maximum height attained

$$= \frac{u^2 \sin^2\theta}{2g} = \frac{(20)^2 \times \sin^2 30°}{2\times 10} = 5\text{m}$$

(c) The horizontal range

$$= \frac{u^2 \sin 2\theta}{g} = \frac{(20)^2 \times \sin(2\times 30°)}{10} = 34.64\text{m}$$

(d) The time of flight

$$= \frac{2u\sin\theta}{g} = \frac{2\times 20\times \sin 30°}{10} = 2\text{s}$$

2. Let u be the velocity of projection of the ball. The ball will cover maximum horizontal distance when angle of projection with horizontal, $\theta = 45°$. Then $R_{max} = \frac{u^2}{g} = 100$ m

If ball is projected vertically upwards ($\theta = 90^0$ from ground) then H attains maximum value,

$$H_{max} = \frac{u^2}{2g} = \frac{R_{max}}{2}$$

$\therefore$ the height to which cricketer can throw the ball is $= \frac{R_{max}}{2} = \frac{100}{2} = 50$ m.

3. $\frac{H_1}{H_2} = \frac{\sin^2\alpha}{\sin^2(90°-\alpha)} = \tan^2\alpha$

$\frac{R_1}{R_2} = \frac{\sin 2\alpha}{\sin 2(90°-\alpha)} = 1$

4. For the first ball, angle of projection = θ, velocity of projection, u = 40 m/s.

Let h be the maximum height attained by it.

As maximum height attained $= \frac{u^2\sin^2\theta}{2g}$

$$\therefore \quad h = \frac{(40)^2 \sin^2\theta}{2\times 10} \qquad .....(1)$$

For second ball, Angle of projection = $(90° - \theta)$.

velocity of projection, u = 40 m/s

Maximum height reached = (h + 50) m

$$\therefore \quad h + 50 = \frac{u^2\sin^2(90°-\theta)}{2g} = \frac{(40)^2\cos^2\theta}{2\times 10}$$

.....(2)

By adding (1) and (2),

$$2h + 50 = \frac{(40)^2}{2\times 10} \times (\sin^2\theta + \cos^2\theta) = \frac{(40)^2}{2\times 10} = 80$$

$\Rightarrow$ 2h = 80 – 50 = 30 $\Rightarrow$ h = 15 m

Height of the first ball, h = 15 m & Height of the second ball = h + 50 = 15 + 50 = 65 m

5. $R = \frac{u^2\sin(2\times 15°)}{g} = 1.5$ or $\frac{u^2}{g}\times\frac{1}{2} = 1.5$

or $\frac{u^2}{g} = 3$ km

Horizontal range for angle of projection 45° is

$$R' = \frac{u^2}{g}\times\sin(2\times 45°) = \frac{u^2}{g}\sin 90° = \frac{u^2}{g} = 3\text{km}$$

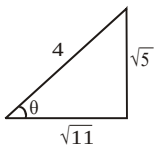
6. $H_m = \frac{u^2\sin^2\theta_0}{2g}$; $R = \frac{u^2}{g}\sin 2\theta_0 = \frac{2u^2}{g}$

$\sin\theta_0.\cos\theta_0$

$$\frac{H_m}{R} = \frac{1}{4}\tan\theta_0 \Rightarrow \theta_0 = \tan^{-1}\left(\frac{4H_m}{R}\right)$$

7. Since their time of flight is same so their vertical velocity will be same, maximum heights attain by them will be same

8. $H \le 25$ m



$$\Rightarrow \frac{u^2}{2g}\sin^2\theta \le 25 \text{ m}$$

$$\Rightarrow \sin^2\theta \le \frac{25}{80} = \frac{5}{16}$$

$$\Rightarrow \sin\theta \le \frac{\sqrt{5}}{4}$$

For maximum range $\sin\theta = \sqrt{\frac{5}{4}}$

$$\tan\theta = \sqrt{\frac{5}{11}} \Rightarrow R = \frac{4H}{\tan\theta} = \frac{4\times 25}{\sqrt{5/11}} = 148.32 \text{ m}$$

TG: @Chalnaayaaar

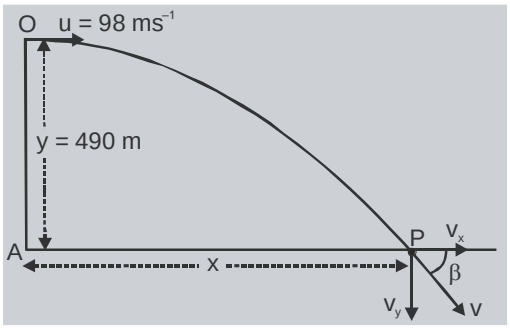
BEGINNER'S BOX-8

1. (i) The projectile is fired from the top O of a hill with velocity u = 98 m/s along the horizontal OX. It reaches the target P vertical distance

OA = y = 490 m

As $y = \frac{1}{2} gt^2$

$\therefore\ 490 = \frac{1}{2} \times 9.8\, t^2$



or $t = \sqrt{100} = 10\,s.$

(ii) Distance of the target from the hill is

AP = x = horizontal velocity × time

= 98 × 10 = 980m.

(iii) The horizontal components of velocity v of the projectile at point P is v_x = u = 98 m/s

and vertical component

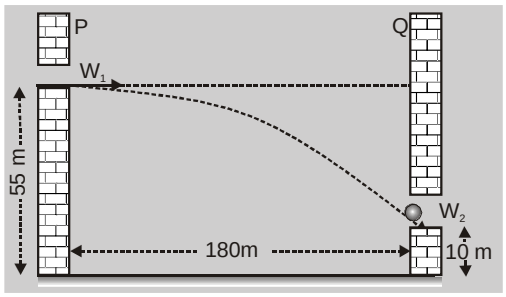
$v_y = u_y + gt = 0 + 9.8 \times 10 = 98$ m/s

If the resultant velocity v makes angle β with the horizontal, then

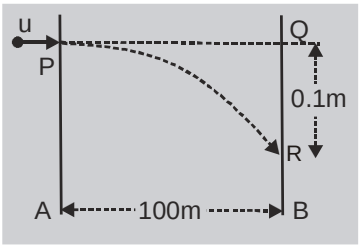
$\tan\beta = \frac{v_y}{v_x} = \frac{98}{98} = 1$ or β = 45°

2. Equation of trajectory $y = \frac{gx^2}{2u^2}$

$45 = \frac{10\times(180)^2}{2u^2} \Rightarrow u = 60$ m/s



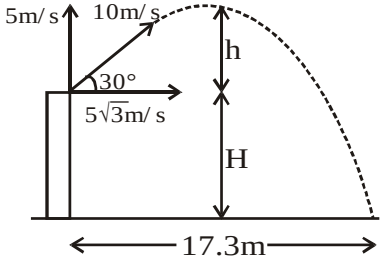
3. Assume that the bullet hits the screen A with velocity u and pierces the screen B after time t.



equation of trajectory $y = \frac{gx^2}{2u^2}$

$(10 \times 10^{-2}) = \frac{9.8\times(100)^2}{2u^2} \Rightarrow u = 700$ m/s

4. Total flight time



$R = u_x T$

$T = \frac{R}{u_x}$

$T = \frac{17.3}{5(1.73)} = 2$sec.

Time to reach maximum height = $\frac{5}{g} = 0.5$ sec.

$h = \frac{1}{2} g(0.5)^2 = 1.25$ m

$H + h = \frac{1}{2} g(1.5)^2 = 11.25$ m

So H = 10 m

BEGINNER'S BOX-9

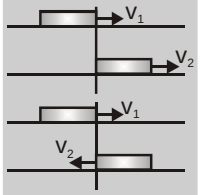
1. In case of overtake

$v_1 - v_2 = \frac{100}{40} = 2.5$

In case of crossing

$v_1 + v_2 = \frac{100}{20} = 5$

Adding, $2v_1 = 7.5$



$\Rightarrow$ $v_1 = 3.75$ m/s and $v_2 = 1.25$ m/s

2. Let s = distance between the trains initially
Velocity of train B w.r.t. A is zero, acceleration of train B w.r.t. A is = 1 m/s²

distance $s_{rel} = u_{rel}t + \frac{1}{2}a_{rel}t^2 = 0 + \frac{1}{2} \times (50)^2$

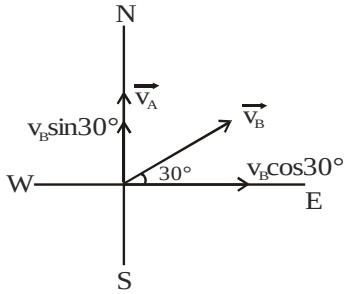
$= 1250\text{m}$

3. $T = \frac{2u_{rel}}{a_{rel}} = \frac{2\times 49}{9.8} = 10\text{ s}$

since the lift is not accelerating, time of flight will remain same.

BEGINNER'S BOX-10

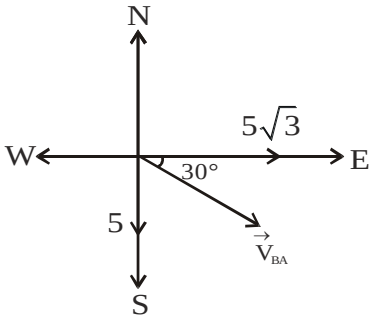
1.



$\overrightarrow{v_A} = 10\hat{j}$

$\overrightarrow{v_B} = 5\sqrt{3}\hat{i} + 5\hat{j}$

$\overrightarrow{v_{BA}} = \overrightarrow{v_B} - \overrightarrow{v_A} = 5\sqrt{3}\hat{i} - 5\hat{j}$

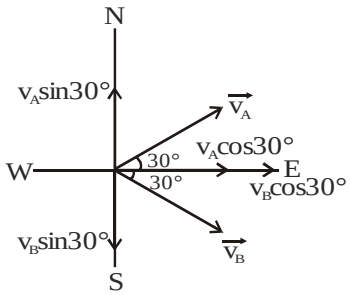


angle with east direction

$\tan\theta = -\frac{5}{5\sqrt{3}} = -\frac{1}{\sqrt{3}}$

$\theta = 30°$ i.e. E – 30° – S

2.



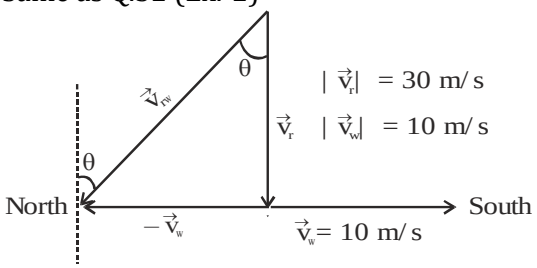
$\overrightarrow{v_{AB}} = \overrightarrow{v_A} - \overrightarrow{v_B}$

$\overrightarrow{v_{AB}} = \left(5\sqrt{3}\hat{i} + 5\hat{j}\right) - \left(5\sqrt{3}\hat{i} - 5\hat{j}\right)$

$= 10\hat{j}$ m/s i.e. 10 m/s in north direction

3. Same as Q.32 (Ex.-2)

4.



From the diagram

$\tan\theta = \frac{10}{30} = \frac{1}{3}$

So $\theta = \tan^{-1}\left(\frac{1}{3}\right)$ from vertical towards south

5. $\overrightarrow{v_m} = 2\hat{i} + 3\hat{j}$; $\overrightarrow{v_{rm}} = -4\hat{j}$

$\overrightarrow{v_r} = \overrightarrow{v_{rm}} + \overrightarrow{v_m} = 2\hat{i} - \hat{j}$

Now velocity of man $\overrightarrow{v_{m'}} = -2\hat{i} - 3\hat{j}$

$\overrightarrow{v_{rm'}} = \overrightarrow{v_r} - \overrightarrow{v_{m'}} = 4\hat{i} + 2\hat{j}$

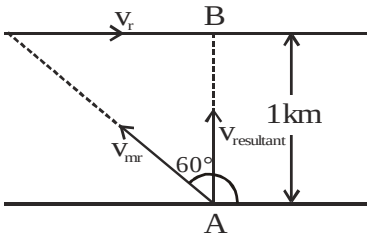
$\left|\overrightarrow{v_{rm'}}\right| = \sqrt{20}$ m/s

6. For bodies to collide the vertical velocities should be same

$\Rightarrow u_1 \sin 60° = u_2 \Rightarrow \frac{u_1}{u_2} = \frac{2}{\sqrt{3}}$

BEGINNER'S BOX-11

1. (a) $\sin 60° = \frac{v_r}{v_m}$



$\Rightarrow v_r = \frac{2\sqrt{3}}{2} = \sqrt{3}$ m/s

(b) $t = \frac{1000}{2\cos 60°} = 1000$ sec.

2. For shortest path

(a) $\sin\theta = \frac{v_r}{v_{mr}} = \frac{1}{2} \Rightarrow \theta = 30°$

So direction from downstream = 90° + 30° = 120°

(b) crossing time $T = \frac{d}{v_{mr}\cos\theta} = \frac{2}{10\cos 30°}$

$T = \frac{2}{5\sqrt{3}}$ h

TG: @Chalnaayaaar

3. (a) Speed of the child running in the direction of motion of the belt
= 9 + 4 = 13km/h

(b) Speed of the child in opposite direction of the motion of the belt
= 9 – 4 = 5km/h

(c) Since both the parents and child are on the moving belt. So their relative position and speed remain unchanged.

$$\text{speed of child} = 9 \times \frac{5}{18} = 2.5 \text{ m/s},$$

$$\text{time taken} = \frac{\text{distance}}{\text{speed}} = \frac{50}{2.5} = 20\text{s}$$

If the motion is viewed by one of the parents answer to (a) and (b) are altered while answer to (c) remain unchanged.